MP 8: Quantum Field Theory II

Time: Wednesday 9:30–13:00 Location: HL 001

Invited Talk MP 8.1 Wed 9:30 HL 001

Embezzlement of entanglement, quantum fields, and the classification of von Neumann algebras — •Alexander Stottmeister — Leibniz University Hannover

Embezzlement refers to the counterintuitive possibility of extracting entangled quantum states from a reference state of an auxiliary system (the "embezzler") via local quantum operations while hardly perturbing the latter. We report a deep connection between the mathematical classification of von Neumann algebras and the operational task of embezzling entanglement: The performance of a general state at the task of embezzling is measured by the flow of weights. In particular, embezzling states, having the best performance, are fixed points of the flow of weights. For a type III factor, its subtype is precisely recovered by the worst possible performance. Our result implies, under typical assumptions, that relativistic quantum fields are universal embezzlers, thereby providing an operational characterization of the infinite amount of entanglement present in the vacuum state: Any entangled state of any dimension can be embezzled from them with arbitrary precision.

This is joint work with L. van Luijk, H. Wilming, and R.F. Werner.

MP 8.2 Wed 10:00 HL 001

The Bałaban variational problem in the non-linear sigma model — •Wojciech Dybalski[1], Alexander Stottmeister[2], and Yoh Tanimoto[3] — [1]AMU Poznań — [2]University of Hannover — [3]University of Rome "Tor Vergata"

The minimization of the action of a QFT with a constraint dictated by the block averaging procedure is an important part of the Bałaban's approach to renormalization. It is particularly interesting for QFTs with non-trivial target spaces, such as gauge theories or non-linear sigma models on a lattice. We analyse this step for the O(4) non-linear sigma model in two dimensions and demonstrate in this case how various ingredients of the Bałaban approach play together. First, using variational calculus on Lie groups, the equation for the minimum is derived. Then this non-linear equation is solved by the Banach fixed point theorem. This step requires detailed control of the lattice Green functions and their integral kernels via random walk expansions.

MP 8.3 Wed 10:20 HL 001

On separable states in relativistic QFT — •Ko Sanders — Friedrich-Alexander Universität Erlangen-Nürnberg

In quantum theory, entanglement is the rule rather than the exception: systems naturally entangle themselves with their environment at no cost to the experimenter. On the contrary, to prevent this decoherence is difficult and expensive in terms of effort and energy. In this talk I will discuss a recent quantitative result on the amount of energy needed to ensure the existence of separable (i.e. non-entangled) states in relativistic quantum field theory, which are physically perfectly reasonable (quasi-free, Hadamard, highly symmetric). This result can be seen as a first step in a general investigation of the balance between energy and entanglement in relativistic QFT.

MP 8.4 Wed 10:40 HL 001

Quantum energy inequalities in integrable models — •Jan Mandrysch — Department Mathematik, FAU Erlangen

While the positivity of the total energy in a system, also in quantum physics, is a hallmark of stability, locally, energy may be negative. For physically reasonable models a reminiscent notion of stability can be captured by weaker conditions often referred to as quantum (weak) energy inequalities (QEIs). Such inequalities have been proven in many free QFT models and are known to be equivalent to other common stability properties. However, there exist only few results in theories with self-interaction.

In this talk, we will focus on a certain class of two-dimensional interacting QFTs known as *integrable models*. In particular, we present results on the O(N)-nonlinear-sigma and sinh-Gordon model at one- and two-particle level.

The talk is partly based on 2302.00063.

20 min. break

MP 8.5 Wed 11:20 HL 001

Stochastic quantization of two-dimensional $P(\Phi)$ Quantum Field Theory — Paweł Duch, Wojciech Dybalski, and •Azam Jahandideh — Adam Mickiewicz University in Poznań, Poznań, Poland

We give a simple and self-contained construction of of the $P(\Phi)$ Euclidean Quantum Field Theory in the plane and verify the Osterwalder-Schrader axioms: translational and rotational invariance, reflection positivity and regularity. In the intermediate steps of the construction we study measures on spheres. In order to control the infinite volume limit we use the parabolic stochastic quantization equation and the energy method. To prove the translational and rotational invariance of the limit measure we take advantage of the fact that the symmetry groups of the plane and the sphere have the same dimension. This talk is based on [arXiv: 2311.04137].

MP 8.6 Wed 11:40 HL 001

Mourre theory and asymptotic observables in local relativistic quantum field theory — •Janik Kruse — Adam Mickiewicz University in Poznań, Uniwersytetu Poznańskiego 4, Poznań, Poland

A classical problem in scattering theory is the problem of asymptotic completeness (i.e. interpreting quantum theories in terms of particles). Asymptotic completeness is settled in non-relativistic quantum mechanics for many-body systems but a widely open problem in local relativistic quantum field theory (QFT). Many proofs of asymptotic completeness in quantum mechanics rely on the convergence of asymptotic observables. In QFT, Araki-Haag detectors have been identified as natural asymptotic observables. The convergence of Araki-Haag detectors on scattering states of bounded energy was established relatively early by Araki and Haag, but the convergence on arbitrary states has remained an open problem for decades. First convergence results of Araki-Haag detectors on arbitrary states have been obtained relatively recently by Dybalski and Gérard by translating quantum mechanical propagation estimates to QFT. They covered products of two or more Araki-Haag detectors sensitive to particles with distinct velocities, but the convergence of a single detector was not treated. The technical reason for this omission was a missing low velocity propagation estimate, which is usually proved by Mourre's conjugate operator method. So far, Mourre theory resisted any extension from quantum mechanics to quantum field theory. In a recent publication, we closed this gap and established the convergence of a single Araki-Haag detector. Based on https://arxiv.org/abs/2311.18680.

MP 8.7 Wed 12:00 HL 001

Quantum Field Theory at Finite Temperature — •Johannes Grosse and Gandalf Lechner — Department of Mathematics, FAU Erlangen-Nürnberg

In this work, we study the finite temperature behaviour of a $(1+1)$-dimensional fermionic quantum field theory of two particle types. As the thermal equilibrium behaviour of one particle type is well-known, the main work focuses on extending thermal equilibrium states from a theory consisting of one particle type to that of two particle types. The issue of extending thermal equilibrium states can be naturally framed in the language of Tomita-Takesaki modular theory and $\mathbb{Z}_2$ crossed products.

MP 8.8 Wed 12:20 HL 001

Lorentz symmetry violating Lifshitz-type field theories — •Emiliano Rizza[1,2] and Dario Zappalà[2] — [1]Jagiellonian University, Krakow, Poland — [2]Università di Catania, Catania, Italy

We discuss the ultraviolet sector of 3+1 dimensional Lifshitz-type anisotropic higher derivative scalar, fermion and gauge field theories, with anisotropy exponent z=3 and with explicit breaking of Lorentz symmetry. By discarding from the action all momentum dependent vertex operators, which is essential to avoid phenomenologically unacceptable deformations of the light cone, we find that renormalizable scalar self-interaction and Yukawa-like couplings are, in general, asymptotically free. However, the requirement of cancelling momentum dependent vertex operators is incompatible with gauge symmetry and, therefore, for this kind of theories, gauge symmetry as well as Lorentz symmetry are recovered only as emergent properties below some energy scale M, that must be constrained from experiments. The quantum corrections to the scalar mass and their impact on the hierarchy problem are also analyzed.

MP 8.9 Wed 12:40 HL 001

Resummations for semiclassical effective actions — •Sebastián A. Franchino-Viñas[1], César García Pérez[2], Diego Mazzitelli[3], Vincenzo Vitagliano[2], and Ulises Weinstein Haimovichi[4] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Università di Genova, Genoa, Italy — [3]Instituto Balseiro, Bariloche, Argentina — [4]Universidad Nacional de La Plata, Argentina

The effective action determines the quantum behaviour of a quantum field. In a variety of situations when the field interacts with other fields, it is enough to approximate the latter fields as classical backgrounds. Employing heat-kernel methods, we show that resummations can be obtained for a variety of background fields, obtaining thus Euler–Heisenberg-type effective actions.